NOTES ON THE BIONOMICS OF MELLITA[1]

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OBSERVATIONS already recorded[2] led me to devote some attention to the movements and the coloration of *Mellita sexies-perforata,* and to the injuries which are in nature inflicted upon the individuals of this species. The findings incidentally supplement and confirm some deductions made in the notes cited,[2] and serve to indicate several directions in which further study would seem promising.

Mellita lives more or less completely buried in the sand, in channels between islands, at the outlets of sounds, and between the shore and the inner reefs; but always in places where there is a tidal current. The character of the bottom, which may lie 2 to 6 fathoms beneath low water, varies from shell-sand, gray-white and usually muddy, to dark brownish mud. Young and adults of all sizes up to 13 cm. transverse diameter occur in company. The older individuals burrow more deeply than the young ones, the latter frequently lying freely exposed on the surface of the sand. In stormy weather, all the Mellitas dig themselves deep into the mud, to a depth of perhaps 8–9 cm. In the laboratory the older individuals burrow more quickly when exposed to bright sunlight than they do in the dark. Heliotropism, when horizontal light is used, is not precise; younger individuals tend, on the whole, to move away from a source of horizontal light. Normally, light coming from above may be a significant source of stimulation; this was not adequately tested. The low degree of photic irritability toward horizontal light probably accounts for the fact that no photic orientation, strictly speaking, was noted; such orientation might be expected, since the nature of Mellita's locomotion would make it possible.

In locomotion on a solid surface, that part of the body anatomically the anterior is always carried ahead. The "leading"

[1] Contribution from the Bermuda Biological Station for Research, No. 118.

[2] Crozier, W. J., 1918, "On the pigmentation of a Clypeastroid, *Mellita sesquiperforatus* Leske," AMER. NAT., 52, 552–555. 1919, "On Regeneration and the Re-formation of Lunules in *Mellita,*" AMER. NAT., 53, 93–96.

point may shift progressively from side to side during an extended act of creeping, but *at all times* some part within the two anterior interradii is in advance. *Mellita* can, however, pivot in complete circles, in either direction, about its mouth as a center; it also carries out successive incomplete swings, alternately opposite in direction. Movements of the latter type, together with the relatively fixed direction of creeping, namely anteriorly, are important for the act of burrowing, and are correlated with some notable growth-changes in the form of the whole body.

During burrowing the anterior end is in advance. The process of concealment is a fairly rapid one, a large specimen being able to disappear completely in less than 15 minutes, although two to three times this interval may be employed. Not only do the spines and tube feet assist in clearing a way through the sand, by moving the individual sand grains, but, in addition, the body as a whole is used as a digging instrument. The disk is repeatedly rotated 30° or more to either side of the sagittal line,

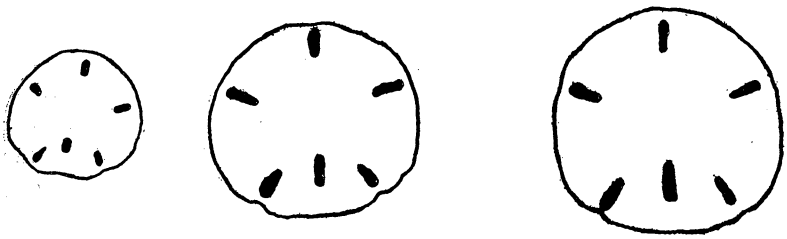
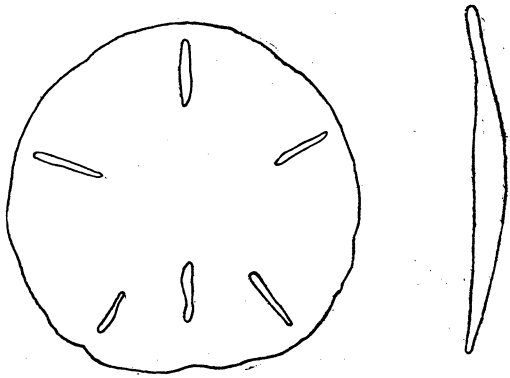


FIG. 1. Outlines of three young *Mellita sexies-perforata,* showing the approximately circular outlines of the body; between the specimens of intermediate and largest size is an antero-posterior section of the former. Attention may be called to the persistence of the marginal notches opposite the two posterior ambulacral lunules, although these lunules, in *M. sexies-perforata,* are formed by the meeting of dorsal and ventral invaginations, not by the inclusion of reëntrant marginal notches—as is the case in other *Mellitas.* (×1.)

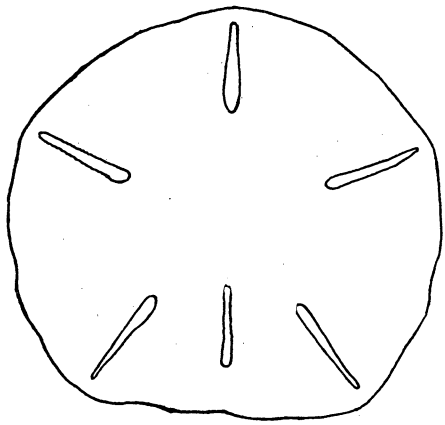
with the result that, since the very numerous spines and tube feet are simultaneously pressing the disk forward, the animal is actually insinuated, or "slid," into the ground. This maneuver is especially effective upon a muddy bottom, where movement of sand by the tube feet and spines would be a slow and inefficient process.

The young *Mellita* is quite thin and wafer-like, its outline practically circular (Fig. 1). As the animal grows, the thickness of the body increases, although the edge of the disk remains thin. In many cases the outline of the disk is still almost cir-

cular even in specimens of maximal size, and the ventral surface of the disk practically flat (Fig. 2). It frequently happens, however, that the central region of the body becomes relatively thicker than in the flat, circular sea-plates, and in these individuals there are several noteworthy departures from the typical structure. Anteriorly the disk is more wedge-shaped in vertical



2 a,

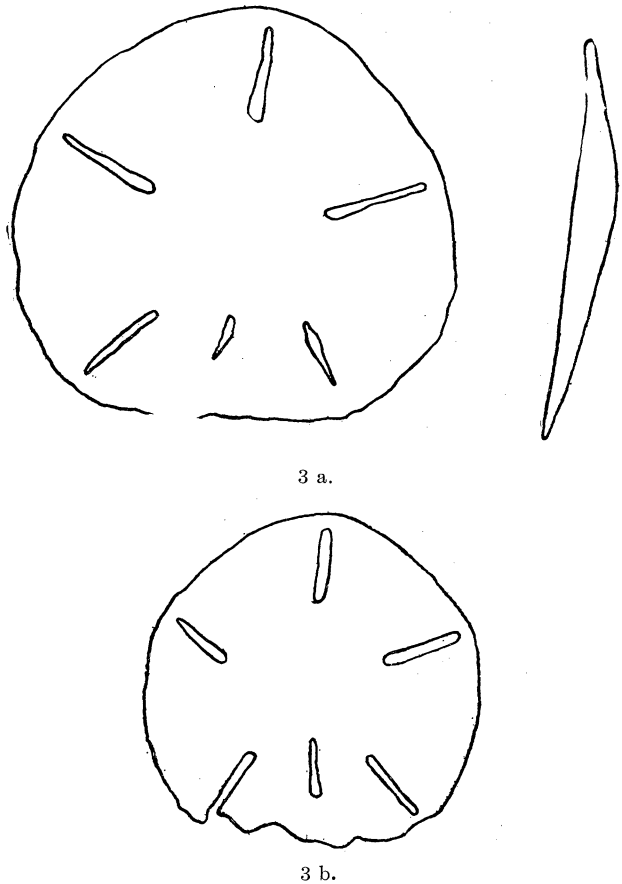


2 b,

FIG. 2. Outlines of two individuals with circular type of margin, with a sagittal section of one of them (*A*). (× 2½.) In this section, and in the following ones, it will be observed that the anterior margin of the disc is more bluntly rounded than that at the posterior edge—an advantage, presumably, since the burrowing portion of the periphery is thus made stronger.

section; the anterior antimere projects forward, forming a sharp "nose," or entering point, which presumably facilitates burrowing (Fig. 3^A). The antero-lateral radius on either side

sometimes forms, in addition, a more or less projecting "shoulder" (Fig. 4). These departures from the smoothly circular form, together with the "arched" construction of the test in some older specimens (Fig. 4), derive their effectiveness for



3 a.

3 b.

FIG. 3. Outlines of two individuals with projecting anterior radii, and a sagittal section of one of them. (× ½.)

burrowing from the partial rotation or "swinging" of the disk during this act.

The changes here noted in the form of the body of some individuals with advancing growth, are not detectably correlated with peculiarities of habitat. The different types occur with about the same relative frequency whether the bottom is of shell sand or of brownish mud. The local character of the bottom

changes somewhat, however, from time to time, being more muddy and less sandy in some years than in others. One may nevertheless entertain the idea that genetic factors are concerned in determining the growth-changes in the body-shape of some individuals. This matter should be studied in a larger series of specimens than I have been able to secure in the time devoted to this work. Especially interesting is the fact that this

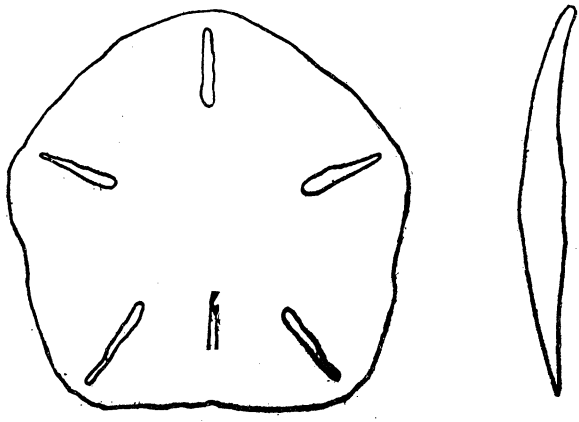


FIG. 4. Outline and sagittal section of a *Mellita* pointed anteriorly and with lateral "shoulders"; the section shows the tendency toward an arching of the test in some of these cases.

species occurs in the fossilized state above the beach zone along the shores of islands in Great Sound. The seven large fossil tests I have examined were all of the almost perfectly circular type (cf. Fig. 1).

In order to follow more precisely the course of growth-changes in *Mellita,* I endeavored to derive the curve of its growth, and to fix the average duration of its life. The results, which are provisional only, are given in Fig. 5. Specimens were measured from one locality—Cobbler's Cut, Spanish Point—in September. The *transverse* diameter was measured, since it is less subject than is the antero-posterior to fluctuations induced (a) by the tendency, already noted, to form a projection at the anterior antimere, and (b) through injuries suffered at the posterior inter-radius. From the modes in the frequency distribution of sizes, it was deduced that at 6-months *M. sexies-perforata* measures 2.2 cm. in transverse diameter; at 1.5 years, 5.7 cm.; and so on, as indicated in Fig. 5. It seems possible that the average duration of life is about 4 years, according with the fact that

the majority of the dead tests, which may be collected in quantity, are about 10 cm. in transverse diameter. From these estimates of age in *Mellita*, the described growth-changes in the form of the body begin to become obvious during the third year of an individual's life; in some specimens they do not occur at all.

During the middle years of its life, *Mellita* has a considerable capacity of withstanding injuries (cf. Fig. 6) and of repairing damage done to the periphery of its body. I have already noted the fact that injured and regenerating individuals are found to have been damaged at the *posterior* end only; the wound illus-

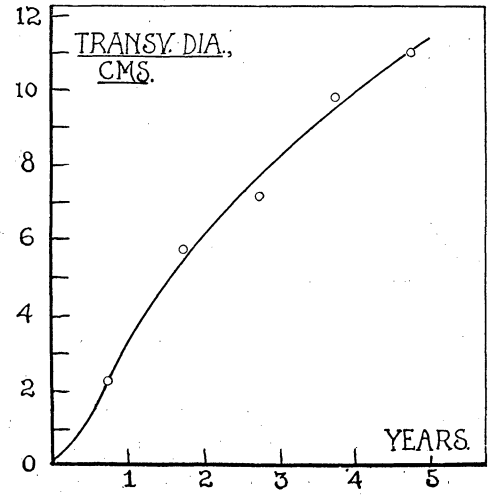


FIG. 5. Possible growth curve of M. *sexies-perforata*.

trated in Fig. 6 is unusually far forward. It was previously suggested (Crozier, 1919) that the posterior incidence of injuries resulted from the circumstance that the posterior end was more freely exposed than the rest of the body. Observations in aquaria and on sand-beaches have shown this explanation to be probably correct. Burrowing takes place with the anterior end in advance, the edge of the posterior inter-ambulacral area frequently remaining exposed long after the rest of the creature has been concealed beneath the sand. The experimental tests were made with active, healthy, specimens exhibiting no green areas upon their surface (cf. Crozier, 1918). During burrowing, the body of the sea-plate is moreover tilted, anterior end down, at an angle of 10°–20° with the surface of the sand; so

that the exposed posterior or postero-lateral margin projects in a not inconspicuous way above the general level of the sand.

In the light of this behavior, and particularly because of the injuries found to have been suffered by the sea-plates, it becomes pertinent to inquire whether an adaptive (concealing) value attaches to the pigmentation of these animals. The occurrence of injured specimens, and that in some degree of frequency (about 60 per cent. of those above 9 cm. transverse diameter), would seem in itself to be valuable evidence upon this point. There are several other important considerations to be derived from the nature of the pigmentation of *Mellita.*

Until it has attained a diameter of 7 to 8 cm., the young *M. sexies-perforata,* seen from above, is practically colorless; the integument contains no pigment, although the yellow-brown stomach may show faintly through the test. Upon attaining this size, a light coffee-tint, evenly distributed upon the dorsum, makes its appearance; previously, at about 5.7 cm. diameter, dark brown pigment begins to show on the *ventral* surface, on each of the polygonal areas surrounded by the tube-foot channels. Pigment thus begins to be deposited on the ventral side; and it continues to be denser (darker) on this side than dorsally. The intensity of pigmentation increases progressively with age, until, in animals on 12–13 cm. diameter, a very dark brown hue is attained.

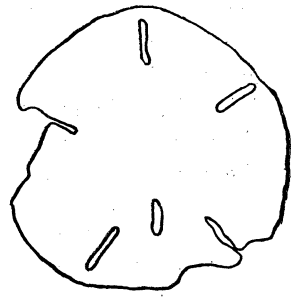


FIG. 6. Illustrating natural injury and initial stages of repair. From the living animal. (× ½.)

M. sexies-perforata, at Bermuda, does not frequent bottoms supporting a good growth of eel-grass. If in other regions it should be found to do so, the alkali-greening substance occurring in this species (Crozier, 1918) and in Clypeastroids generally, might be adaptively concerned in pigmentation. But no green hues are normally evidenced by this species at Bermuda. If the somewhat uncertain records of a green coloration in normal mellitas of this species at more southerly stations are confirmed, and found related to an eel-grass habitat, a direct physical explanation is at hand to account for the greening (cf. Crozier, 1918). The normal brown hue seems due to the integu-

mentary accumulation of some metabolic waste. This view in itself does not preclude the possibility of an adaptive determination of the pigmentation; it would be curious indeed if an internal coloring-matter were not the result of metabolism. In order to remove the possibility of an explanation for the coloration in the customary terms of adaptation, it must be shown that the pigmentation in question is an *unconditioned* result of metabolic processes—unconditioned, that is, by the "need" for concealment and the like. It is, therefore, important to observe that: (1) the degree of pigmentation increases with age; (2) the variously colored individuals live side by side; (3) the tilting of the body exhibited during burrowing, and the exposure of the posterior margin of the body owing to the incompleteness of this act, are not compensated by counter shading—the ventral surface is more darkly colored than the dorsal; and (4), the region known to be differentially exposed in this way is found actually to bear evidence of damage, in a goodly proportion of individuals. The exact origin of these injuries remains obscure, but is not of primary importance here.[3]

The general physiology of pigmentation in the sand-dollars and sea-plates, and the possible evolutionary significance of the growth changes in body-form noted in this paper, should be made the topics of further studies.

DYER ISLAND, BERMUDA, 1918.

[3] I have good reason to believe that the injured mellitas were not damaged as the result of antecedent dredging operations in the same areas.